Accident investigation and reconstruction

By Shane Richardson, Dr George Rechnitzer, Dr Raphael Grzebieta and Dr Roger Zou

In crash reconstruction, one of the objectives is to determine vehicle paths pre- and post-impact. This includes vehicle velocity (direction and speed), crash severity and occupant paths (kinematics). A number of sophisticated computer programs have been developed to carry out such analysis. These computer simulation tools can be used to present dramatic and persuasive imagery of a collision. They fall in to three broad categories of increasing complexity:

1. Momentum analysis;
2. Energy and momentum analysis; and
3. Engineering analysis.

MOMENTUM ANALYSIS

A momentum analysis is relatively simple and therefore the cheapest option.

The typical tools include Win-smack. The momentum analysis is based on Newton's laws of motion and the premise that momentum is conserved (law of conservation of momentum). The typical variables are vehicle masses, friction factors, wheels skidding, skidding distance, vehicle rest positions, road geometry, start positions and speeds.

Momentum analysis should be used when two or more vehicles collide when in motion, but not when a vehicle collides with a fixed object such as a pole. Nor should it be used when there is a large mass difference between the colliding objects (greater than 10 to 1), such as when a passenger car collides with a B-double semi-trailer.

ENERGY AND MOMENTUM ANALYSIS

An energy and momentum analysis is not as straightforward as a momentum analysis, but it is not overly complicated. It can be moderately expensive but generally provides good results.

Typical tools include PC Crash and HVE, which use a combination of momentum and vehicle crush. The crush of the vehicle is used to estimate the impact energy. This is based on the assumption that the vehicle structure crushes in the same way as a plastically deformable spring. The stiffness of the spring (force-deformation characteristics) is defined by crash tests, and typically vehicles are grouped into similar-size categories. Typical variables are the vehicle masses, position of the centre of gravity, wheelbase, wheel-track width, profile and shape of the vehicle, friction factors, wheels skidding, skidding distance, rest position, road geometry, inertia properties, start positions and speeds.

Extreme care needs to be exercised when vehicle crush is used to evaluate pole collisions, as the vehicle stiffness values are typically derived from broad object crash tests rather than pole crash tests.

Energy methods can also be used to evaluate multiple vehicle crashes. >>

HVE simulation of three-car collision. Note that HVE shows full vehicle deformations resulting from impacts.

ENGINEERING ANALYSIS

Engineering analysis of any crash is possible, but it is complex and the most costly to carry out. It will, however, provide the most realistic and accurate simulation of the collision.

Typical tools include Finite Element or Finite Difference and whole-body modelling programs, such as MADYMO, which simulate both the vehicle crash as well as the motion of people (inside or outside the vehicle/s). Research institutions and manufacturers typically use these tools to develop and investigate safety systems related to impact. Typical variables include detailed models of the vehicle/s and/or the object impacted, and material properties for elements within the models.

CONCLUSION

The fundamental issue with any modelling is that the simulations are dependent on the input variables. A good simulation will contain validation against known facts and should contain some form of sensitivity analysis, which examines how differing variables can affect the result and provides an estimated margin for error in the conclusion of the analysis.

When evaluating other people's simulations, don't rely on pretty colour images of a crash! Copies of the simulations should be requested so that claimed variables and assumptions can be checked.

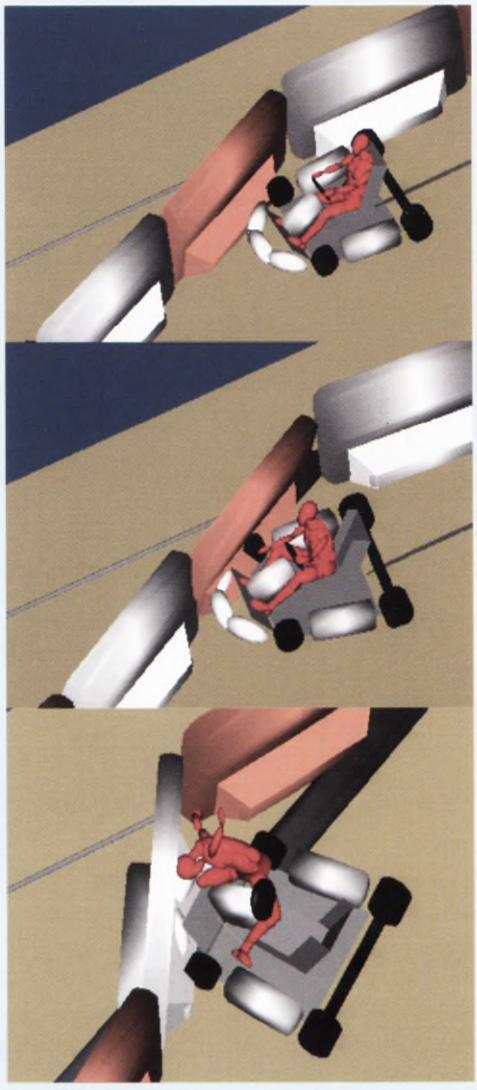
Modern computer simulation tools can certainly provide valuable insights into vehicle collisions, which cannot be achieved in any other way. ■

The authors are all specialists in accident investigation, reconstruction, failure analysis and safety solutions, based with DVExperts International Pty Ltd.

PHONE *(03) 9897 3486* **EMAIL** *dve@dvexperts.net*

WEBSITE *www.dvexperts.net*

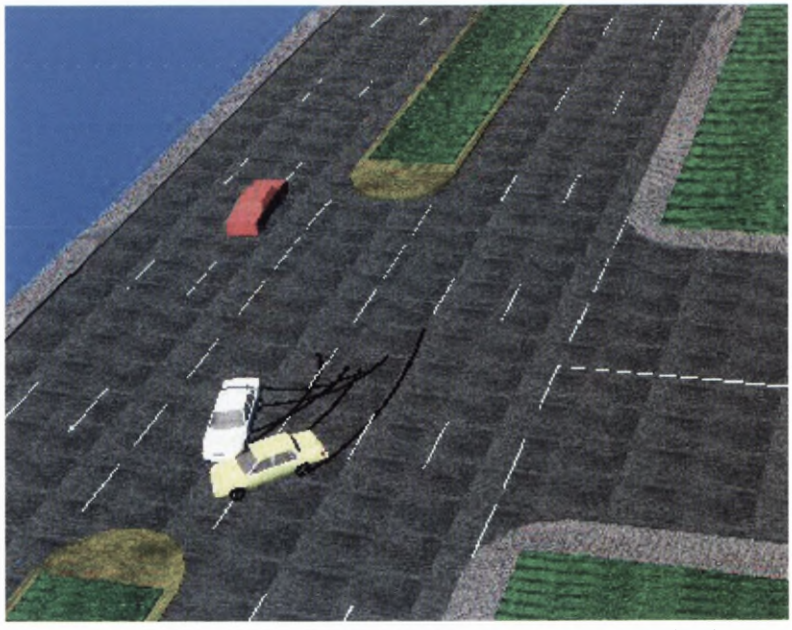
For other examples of computer simulations, visit http://www.dvexperts.net/contentFolder.php?id=18 and click on videos.



- MADYMO simulation of a Go-Kart crashing into a barrier.
- Moment of impact.
- Front tyre of Go-Kart hits bevel edge of barrier.

- Body starts to be propelled forward during impact because of deceleration caused by resistance from barrier.
- Go-Kart pushes barrier back over concrete edging.
- Go-Kart rides up onto barrier.

- Body is thrown forward into barrier. Head contacts barrier, bending the neck and applying large neck loading.
- Go-Kart begins to rotate clockwise and the front left tyre contacts the plastic barrier and edging.
- Left leg has been restrained in Go-Kart.



HVE simulation of two-car intersection impact.